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Voting rules in multilateral bargaining: using an experiment to relax procedural assumptions

James Tremewan and Christoph Vanberg

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Voting rules in multilateral bargaining: using an experiment to relax procedural assumptions

James Tremewan* Christoph Vanberg†

Abstract

Experiments can be used to relax technical assumptions that are made by necessity in theoretical analysis, and further test the robustness of theoretical predictions. To illustrate this point we conduct a three-person bargaining experiment examining the effect of different decision rules (unanimity and majority rule). Our experiment implements the substantive assumptions of the Baron-Ferejohn model but imposes no structure on the timing of proposals and votes. We compare our results to those obtained from an earlier experiment which implemented the specific procedural assumptions of the model. Our results are in many ways very similar to those from the more structured experiment: we find that most games end with the formation of a minimum winning coalition, and unanimity rule is associated with greater delay. However, the earlier finding of "proposer power" is reversed. While some important patterns are robust to the less stringent implementation of procedural assumptions, our less structured experiment provides new insights into how multilateral bargaining may play out in real world environments with no strict procedural rules on timing of offers and agreements.

Keywords: Bargaining; group choice; voting rules; coalition formation; experimental methodology

JEL-Codes: C7, C9, D7

*Department of Economics, University of Auckland; E-mail: james.tremewan@auckland.ac.nz

†Department of Economics, University of Heidelberg; E-mail: vanberg@uni-hd.de

1 Introduction

In economic theory assumptions are often made for technical reasons, not to reflect the environment of interest but for tractability in finding equilibria, or simply because some order of moves must be assumed in order to write down a non-cooperative model. Experimental economists typically implement these assumptions faithfully in the laboratory. However, experiments allow for more flexibility as subjects can be left to interact in a less structured way and determine the order of moves themselves. We argue that when the object of interest is a real world environment rather than the theoretical model itself, it is valuable to relax purely technical assumptions as a step towards external validity. Given that the predictions of theory are assumed to say something about a reality where the assumptions of a model are clearly not met, these predictions should also be useful for generating hypotheses in a laboratory experiment, even if it is not a faithful implementation.

In this paper we illustrate this point in an experiment on multilateral bargaining, an environment where the order of moves in real world applications is often not clearly defined, but a great deal of structure must be imposed in theoretical models to generate equilibrium predictions. In particular, we run an experiment which implements the substantive, but not technical assumptions, of the Baron-Ferejohn model, comparing outcomes under majority and unanimity rule. Hypotheses are derived from the theoretical model and an earlier experiment which faithfully implemented the theoretical model, and we compare the results from the different experimental approaches.[1]

A large literature on multilateral bargaining investigates situations where three or more agents must reach an agreement on the division of some surplus. Areas of application include dividing profits from a joint enterprise, assigning government ministries to members

[1]The question naturally arises, "why not derive predictions from a non-cooperative model of unstructured bargaining?" While some progress has been made in studying non-cooperative models of continuous time bargaining, these cannot be solved without replacing procedural assumptions with assumptions about the rate at which proposals can be altered ("waiting time") or responded to ("reaction time") which are critical to determining equilibria (Perry and Reny, 1993) (we note here that the that assumption made in de Groot Ruiz et al. (2016) that the reaction time is less than the waiting time does not appear to be met in our experiment, where often subjects attempt to agree to a proposal which has just been withdrawn). A more serious problem is multiplicity of equilibria: continuous time multilateral bargaining allows such strategic flexibility that the set of possible divisions is not usefully reduced by subgame perfection or other commonly used equilibrium refinements (de Groot Ruiz et al., 2016).

of a ruling coalition, and so on. Especially in the political context, one important question is how alternative decision rules (e.g. majority or unanimity rule) impact the process and outcome of such negotiations. Such questions have been addressed both theoretically, empirically using naturally occurring data, and experimentally by having subjects bargain in a laboratory setting.

Most recent theoretical work in this area analyses non-cooperative models. Each such model is characterized by a specific set of procedural assumptions which specify which players may take which actions at specific points in time.[2] Perhaps the most prominent example is the random-proposer model originally developed by Baron and Ferejohn (1989) (henceforth: BF model). This model is described in more detail below.

Most recent experiments on multilateral bargaining are designed so as to faithfully implement, as much as possible, such non-cooperative models within the laboratory. For example, a large number of experiments have implemented the BF model using computer programs which randomly select a proposer, allow that subject to enter a proposal, and then allow all subjects to vote, etc. Examples include Agranov and Tergiman (2014); Frechette et al. (2003); Miller and Vanberg (2013, 2015). Such experiments have produced important insights into how well predictions based on equilibrium analysis can capture the behaviour of 'real people' when they are placed into a strategic environment that matches the corresponding model. For example, experiments implementing the Baron and Ferejohn model have shown that most, but not all, of the qualitative predictions of stationary subgame perfect equilibrium (SSPE) are supported.

Although it is common for such experiments to be motivated as *tests of a model*, a more accurate statement may be that what is being tested is not the model itself, but the validity of the equilibrium analysis, or of specific equilibrium concepts. For example, when an experiment implementing the BF bargaining model is conducted, the hypothesis being tested is *not* that this model is a good model of 'real-world' bargaining processes, but that 'real people' behave according to equilibrium predictions when they are placed

[2]Cooperative bargaining theories (Aumann and Maschler, 1961; Davis and Maschler, 1965; Nash, 1953; Shapley, 1952; Schmeidler, 1969) deliberately refrain from making specific procedural assumptions. Instead they investigate the implications of axioms characterizing plausible, stable, or desirable outcomes. As they are independent of procedural assumptions, the corresponding 'predictions' may be applicable to a large set of situations.

in an environment that matches the model *by construction.* To the extent that this is the research goal, it is appropriate to faithfully implement the exact strategic environment assumed in a model. This way, observed deviations from (or 'confirmation' of) equilibrium predictions could be clearly attributed to the failure (or not) of the hypothesis that 'real' subjects pursue equilibrium strategies.

Many experiments are conducted with a different goal in mind. For example, many researchers are interested in testing hypotheses about the effects of certain environmental or institutional factors on bargaining behavior and outcomes. Thus, Miller and Vanberg (2013) (henceforth: MV) investigate the effects of alternative voting rules (unanimity and majority rule) on coalition formation and delay in reaching agreement. In such instances, the specific bargaining model being implemented in the laboratory is used as a kind of "workhorse" - a simple and controlled context within which a single factor can be manipulated in order to identify causal effects. Indeed, the hypotheses being tested in such experiments may not be based on an equilibrium analysis of the corresponding model. The hope is that effects observed within such experiments will reflect those that would occur in 'real world' situations to which that analysis would not strictly apply. For example, MV are ultimately interested in the effects of voting rules on bargaining in real-world decision making bodies such as legislatures. Although their experimental design implements a BF game, their main hypotheses (differences in delay between treatments) are not based on an equilibrium analysis.

For experiments of the latter type, an important question concerns the external validity of the treatment effects observed (or not). To what extent do such effects extend to the real world settings of ultimate interest? For example, MV find that unanimity rule is associated with greater delay in reaching agreement. This raises the question whether that effect is specific to the particular bargaining protocol which was implemented (BF), or does it extend to the real-world contexts which the experimental design is intended to represent?

One of the most important ways in which real world bargaining situations differ from those typically implemented in a laboratory experiment is that they are not as rigidly "structured" as any non-cooperative model. Even in legislatures governed by formal procedural and voting rules, members can engage in informal bargaining activities which are largely “unstructured”. Often, the formal process of proposing and voting on the floor will happen only after such informal negotiations have been completed. None the less, the behavior and results of such bargaining processes is likely to be affected by formal rules such as the majority ultimately required for a proposal to pass.

In order to assess the external validity of experimental results obtained in highly structured laboratory experiments, we conduct experiments that relax this structure, while still maintaining a controlled environment in which a single treatment factor is manipulated. Specifically, we conduct experiments which resemble those of MV in that groups of three individuals will be dividing an exogenously given surplus. Like in the previous experiments, delay in reaching agreement is costly, as the surplus will shrink over time. And we implement two decision rules - majority and unanimity rule. The main difference is that while MV faithfully implement a BF bargaining protocol, we implement a far less structured environment, allowing all three group members to make proposals and / or agree to others’ proposals at any point in real time.

The specifics of our experimental design are described in more detail in Section 3. As will become clear, our setting is arguably closer to the typical structured experiments than it is to the “real world” contexts of ultimate interest. None the less, we believe that relaxing the very rigid structure of prior experiments, while still maintaining a simple environment with exogenous variation in a single treatment variable, can help to assess the external validity of prior results. Our main findings are qualitatively in line with those obtained by Miller and Vanberg (2013). Specifically, we find more delay prior to agreement in the unanimity rule treatment than under majority rule. This suggests that the results obtained under the structured approach extend to a context that is more similar to the ‘real world’ situations of ultimate interest.

In line with prior evidence from structured (BF) experiments, we find that subjects learn to form “minimum wining coalitions”, leading to more inclusive outcomes under unanimity rule. As already mentioned, we find significant delay in coming to an agreement under both decision rules, and that this delay is greater under unanimity rule. This is of particular interest, as it demonstrates that this delay is not driven by the constraints implied by the specific procedure. We do not find evidence of the “proposer power” typically observed in earlier experiments, and in fact find that those who proposed the final agreement in our majority rule treatment tend to receive *less* than their coalition partners. In addition, the rich dataset we have collected allows us to explore the effectiveness of different bargaining strategies used by subjects.

2 Related Literature

The most well-known non-cooperative multilateral bargaining model was developed by Baron and Ferejohn (1989). In that model, a randomly chosen proposer suggests a division of a fixed surplus between themselves and the other players; the proposal is voted on, and if it receives a sufficient number of votes (depending on the voting rule) the proposal is implemented; if the proposal fails, the value of the surplus is discounted and a new proposer is randomly selected. This is repeated until a proposal is accepted. The main theoretical predictions are based on properties of the unique symmetric stationary subgame perfect equilibrium. These include that players build minimum winning coalitions, that the proposer receives a larger share than other coalition members, and that agreement is reached immediately. BF has become a workhorse model that has been extended in various ways by a number of authors (see, for example, Battaglini and Coate, 2007, 2008; Battaglini et al., 2012; Diermeier and Feddersen, 1998; Diermeier and Merlo, 2000; Drouvelis et al., 2010; Duggan et al., 2000; Groseclose and Snyder, 1996; Kalandrakis, 2004; Nunnari and Zapal, 2016; Tergiman, 2015).

Many experiments have been motivated by BF, or one of its variants (see, for example, Agranov and Tergiman, 2014; Battaglini and Palfrey, 2012; Diermeier et al., 2006; Diermeier and Morton, 2005; Frechette et al., 2003, 2005b,a; Kagel et al., 2010; Miller and Vanberg, 2013, 2015). As is typical in experimental economics, these scholars *faithfully* implement the non-cooperative model in the laboratory. That is, the experiments are designed to mimic, as closely as possible, the precise assumptions that make up the decisions of nature, and the strategy sets and payoffs of players that make up the non-cooperative model.[3] Among other things, this means that the random proposer rule is experimentally implemented: one participant in the group is randomly chosen, and only this subject is

[3] All experiments also relax the assumptions made about theoretical decision makers. Nunnari and Zapal (2016) consider theoretical models which differ from BF in allowing imperfect best response and non-equilibrium behaviour.

given the opportunity to make a proposal that round, after which all subjects vote on that proposal, and so on.

The paper most closely related to ours is Miller and Vanberg (2013). They implement a BF game with three players and a discount factor of $\delta = .9$, comparing behavior under majority and unanimity rule. Their main findings are that subjects build (after some experience) minimum winning coalitions. The division of the surplus within coalitions is often equal, with a slight advantage for the proposer. Finally, unanimity rule is associated with greater delay as measured by the fraction of first round proposals that fail. As outlined above, the aim of the current paper is to investigate whether these patterns persist when the procedural assumptions of the BF model are relaxed.

3 Experimental Design

Our experiment implements a three-player bargaining game played in continuous time. All subjects can propose allocations of the available surplus and signal their approval of existing proposals at any time. The game ends when a sufficient number of participants agree on a given division of the available surplus. We conduct two treatments, one in which two subjects must agree (majority rule) and one in which all three must agree (unanimity rule). As in standard BF experiments, delay is associated with costs. Specifically, the available surplus shrinks every 10 seconds. Thus, each ten second interval is comparable to a single bargaining *round* in the Baron-Ferejohn model. Within a bargaining round, however, no restrictions are imposed on the order in which subjects can propose or respond to proposals.

In order to enable subjects to interact flexibly and quickly, we used a simple computer interface. Figure 1 shows two screenshots that illustrate how the interface worked. The bargaining set was represented in the form of a two-dimensional simplex consisting of a finite number of circles. Each circle represents a feasible allocation of the available surplus. The allocation associated with a given circle was displayed if a subject hovered over that circle with the mouse. At any time, subjects could individually select a circle by clicking on it. This was immediately made visible to all subjects by highlighting the chosen circle

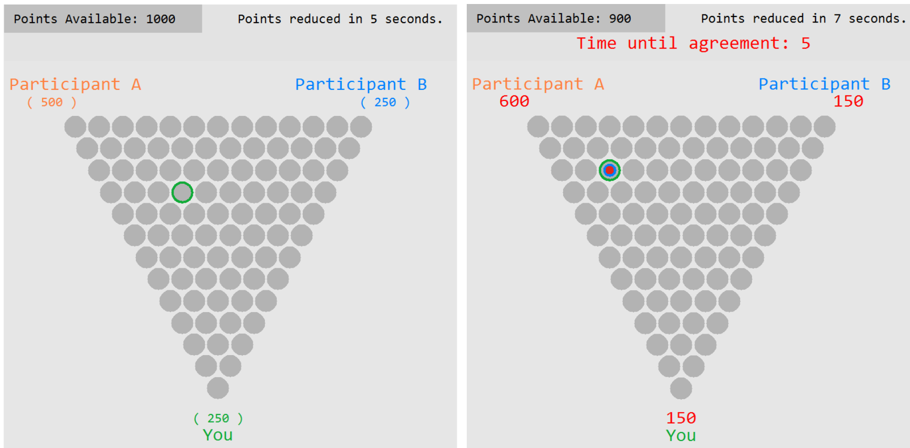


Figure 1: Screen Shot. Left: The green player has selected a circle. The numbers below the player ID's are associated with the circle over which his mouse is hovering (cursor not shown). Right: The blue and green players have agreed on a division. The game will end unless one of the two players clicks elsewhere within the following 5 seconds.

with a color associated with that player (see left panel of Figure 1). Once selected, a circle remained so unless and until the subject clicked elsewhere (either selecting another circle, or outside of the simplex, in which case no circle would be selected by that subject). The game ended when at least two (majority rule) or three (unanimity rule) subjects selected the same circle and remained there for a five second 'ratification' period (see right panel of Figure 1).[4]

The playing screen also contained information about the current size of the surplus (initially 1000 points), and the number of seconds until the surplus would be reduced (by 10% every 10 seconds). When sufficient players had clicked on a circle, a five second countdown appeared indicating the time until the incipient agreement would be implemented if it remained in place (see right panel of Figure 1).

The experiment began with a tutorial which introduced subjects to the interface (see Appendix A for details). Subsequently, subjects played 12 repetitions of either the majority or unanimity bargaining game under a stranger-matching protocol. To increase the number of independent observations, subjects within a session were divided into matching groups

[4]Payoffs depended on the available surplus at the time of initial agreement, even if the surplus had decreased by the end of the ratification period.

Table 1: Breakdown of observations

	subjects	matching groups size 9	matching groups size 6	repetitions	games
majority rule	57	5	2	12	228
unanimity rule	48	4	2	12	192

of size 9. Due to no-shows in two of our sessions, we have four matching groups of size 6 (see Table 1 for details). One game was randomly selected for payment, with each point exchanged for €0.03, i.e. the initial surplus was worth €30. A total of 105 subjects participated in the experiment, earning approximately €14 on average, including a €5 payment for completing a post-experimental questionnaire. Sessions lasted around one hour. The experiment was programmed in z-Tree (Fischbacher, 2007) and conducted at the Vienna Center for Experimental Economics in December, 2012. Subjects were recruited using ORSEE (Greiner, 2015).

4 Hypotheses

Our hypotheses are motivated by existing theoretical and experimental results from the Baron-Ferejohn game. Our aim is to see which ones are robust to our less structured bargaining process, and so we state our hypotheses based on the findings of existing work, and discuss informally any differences we anticipate in our new environment.

In the unique stationary subgame perfect equilibrium of the closed amendment rule model proposed in BF,[5] agreement is reached in the first round for any decision rule, and outcomes are thus efficient. MV, however, finds delay under both unanimity and majority rule, and that it is significantly greater under unanimity. We state our hypothesis with reference to the experimental results:

[5]BF also model an open amendment rule, however we focus on the closed rule as it is far more prevalent in the literature. In fact, for our experimental parameters, there is minimal difference between the predictions of the two models. The one important difference is that the open rule predicts delay under majority rule. In this model delay occurs because of the proposer's uncertainty over which of the other players will be selected to approve or amend a proposal. This mechanism cannot be present in our experiment, as either of the other players can agree or make another proposal at any time.

Hypothesis 1 *Delay: Delay will occur under both decision rules and be more pronounced under unanimity rule.*

One possible explanation for the delay observed in existing experiments is a conflict between proposer power and fairness concerns, leading to miscoordination. As our players are perfectly symmetric, there is no justification for claiming more than an equal share. Also, the continuous nature of play in our design should mitigate any miscoordination. Therefore, one might expect more agreement to occur in the first round in our experiment, under both decision rules.

In BF, when n players are required to pass a proposal, the proposer makes a positive offer to $n-1$ others to form a minimum winning coalition. In all prior experiments such as MV, subjects also tended to form minimum winning coalitions, although less than predicted under majority rule.

Hypothesis 2 *Minimum winning coalitions: Under majority rule, the surplus is divided exclusively among two of the three participants. Under unanimity rule, all three participants receive a positive amount.*

An important feature that distinguishes our setting from experiments based on the BF game is the asymmetry caused by the random selection of a single proposer. In the BF game, the individual randomly chosen to propose in a given round has 'power' for two reasons. First, failure to agree results in the destruction of some of the available surplus (discounting) before an alternative proposal can be considered. The smaller the discount factor, the more the proposal has the character of an ultimatum.[6] Second, the identity of the next proposer, and the content of his counterproposal, are unknown. This further limits the value of rejecting a proposal. MV find experimental evidence of this proposer power, albeit not to the extent predicted by the theory.

In our game, proposals can be introduced at any time within a round (10 sec time interval), and by any player. This means that the identity of a "proposer" arises endogenously. In

[6]With a discount factor of zero, the game reduces to a multi-person ultimatum game and the *homo economicus* prediction is that the proposer is able to keep the entire surplus.

some real-world bargaining environments, especially those governed by well-defined rules about who can make proposals and when (such as in legislatures or negotiations over the formation of coalition governments), there may exist individuals who can be identified as taking the role of proposer at a particular point in time. In this case there is little comparability between proposers in the BF environment and our own. However, in more general unstructured real-life settings, the "proposer" will only be identifiable by the fact that they were the party who initiated a proposal. When trying to understand and explain factors explaining real-life agreements in this context, it becomes meaningful to compare predictions about the share of surplus obtained by the exogenously defined proposers from theory and structured experiments, and the predictions that would come from observing the share obtained by the endogenously arising proposers in an unstructured experiment. As before, we state our hypothesis according to the findings of earlier work, in which theory and structured experiments are in agreement:

Hypothesis 3 *Proposer power: The player making the implemented proposal receives more than an equal in-coaliton share of the surplus (i.e. more than 1/3 and more than 1/2 under unanimity and majority rule, respectively).*

Naturally the absence of proposer power within our game suggests that

However, given the absence of structurally induced proposer power in our implementation, one may expect more symmetric outcomes than observed in earlier experiments.

5 Results

Table 1 summarizes the structure of the data we obtained from the experiment. 57 and 48 subjects participated in the majority and unanimity rule treatments, respectively. In total, we observe 228 and 192 games being played under the two rules, for a total of 420 games.[7]

[7] Of the 420 games we observed, only one did not end with agreement within the three minute maximum. This game occurred in the unanimity rule treatment and in the very first period of that session. Inspecting the data, we saw that one player in this game did not click at all during the entire 3 minutes, suggesting that one subject was simply not participating. This unusual game is therefore excluded from the subsequent analysis.

Our descriptive statistics and figures treat each of these games as a single observation. All significance tests are based on matching group averages of the relevant statistics. These give us 7 and 6 statistically independent observations under majority and unanimity rule, respectively.

We begin this section by testing the three main hypotheses derived from theory and structured experiments, before conducting a more exploratory analysis of individual strategies and their relationship with outcomes.

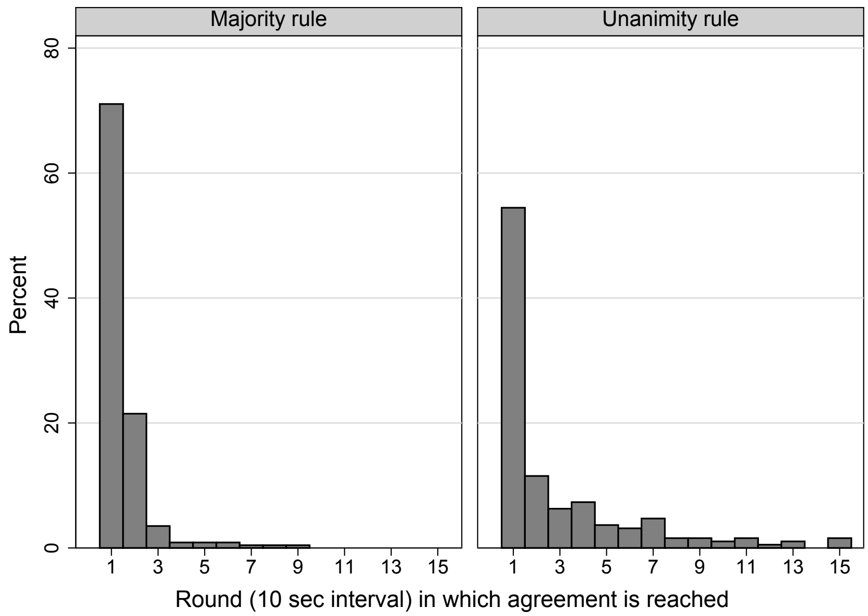
5.1 Time to reach agreement

Figure 2 shows, for each of our treatments, the distribution of the round (i.e. 10 second interval) in which agreement is reached. Since the available surplus shrinks by 10% at the end of each 10 second interval, any delay greater than 10 seconds is inefficient. As can be seen in the Figure, such delay occurs in 25% vs. 46% under majority and unanimity rule, respectively. Consistent with Hypothesis 1, unanimity rule appears to be associated with greater inefficient delay.

As a means of assessing the significance of this result, Table 2 presents multiple measures of delay and efficiency. The first column compares the average time, in seconds, that expiries before agreement is reached. The second column compares the average *round* (10 second interval) of agreement. The third column compares the number of games which end within the first 10 seconds (round 1), and the last column looks at the number of games that end within 20 seconds (round 1 or 2). Finally, the fifth column contains the average total payoff achieved by the group, as a fraction of the maximum available surplus.

Each one of these measures suggest that unanimity rule is associated with significantly longer delays, and consequently lower efficiency, than majority rule. For example, 93% of majority rule games end in agreement within the first 20 seconds, as compared to 66% of unanimity rule games (Wilcoxon rank-sum $p = 0.01$). On average, 15% of the available surplus is lost under unanimity rule, compared to 4% under majority rule (Wilcoxon rank-sum $p = 0.03$). These differences persist, and even increase in significance, when we focus

Figure 2: Time of agreement



on the final 6 periods of the experiment (see bottom half of Table 2).[8]

Result 1 *Delay occurs under both decision rules and is more pronounced under unanimity rule (consistent with Hypothesis 1).*

5.2 Final agreements

We now turn to characterizing the types of distributions that groups agree upon, irrespective of *when* agreement occurs. Thus, we will be pooling agreements that occurred at different points in time (different 'rounds'). In all tables and figures, the shares allocated to different players are expressed as points, each of which is worth 1/12th of the surplus *at the time of agreement*. (Recall that this corresponds to the way that the game was represented to subjects.)

[8] If we focus on only the final three periods, all of the differences in Table 2 remain significant at $p = .01$, except for the fraction ending in round 1 (z=1.67, p=0.1).

Table 2: Delay and efficiency

	average end time (sec)	average end round	fraction ending round = 1	fraction ending round ≤ 2	total payoff
			All periods		
majority rule	8.3	1.4	75%	93%	.96
unanimity rule	24.0	3.9	54%	66%	.85
z†	2.4	2.3	1.93	2.44	2.14
p-value	.02	.02	.05	.01	.03
			Periods 7-12		
majority rule	6.8	1.3	82%	94%	.97
unanimity rule	21.4	2.7	58%	69%	.87
z†	2.71	2.57	2.22	2.74	2.57
p-value	<.01	0.01	0.03	<0.01	0.01

† z stats and p-values reflect a Wilcoxon rank-sum test (2-sided) based on matching group averages. ($N = 6, 7$ for unanimity, majority rule)

Figure 3 presents the distribution of final agreements in the form of a bubble plot within a two-dimensional simplex. The simplex is constructed such that the origin is where the 'proposer', defined as the first subject to click on the finally agreed upon point, secures the entire pie. 'Responder' payoffs are measured along the horizontal and vertical axes, respectively. In order to aggregate equivalent points, responder payoffs are ordered such that the first coordinate is always weakly larger than the second.

Several patterns are visible in these figures. First, we can see that the modal outcomes are the three-way and two-way equal splits under unanimity and majority rule, respectively, and these account for 90% and 50% of all observations. Second, the right panel reveals that the preponderance of majority rule games end with the formation of a minimum winning coalition. These patterns are remarkably similar to those observed in the comparable structured Baron-Ferejohn experiments conducted by Miller and Vanberg (2013). (See Figure 4.) Finally, a somewhat surprising pattern is that the allocations within minimum winning coalitions tend to favor the included responder over the proposer. We will return to this phenomenon in the next subsection.

Table 3 summarizes the prevalence of minimum winning coalitions (MWCs), defined as agreements which allocate positive shares to exactly the number of subjects required to vote 'yes' in order to pass a proposal. Naturally, (almost) all agreements under unanimity

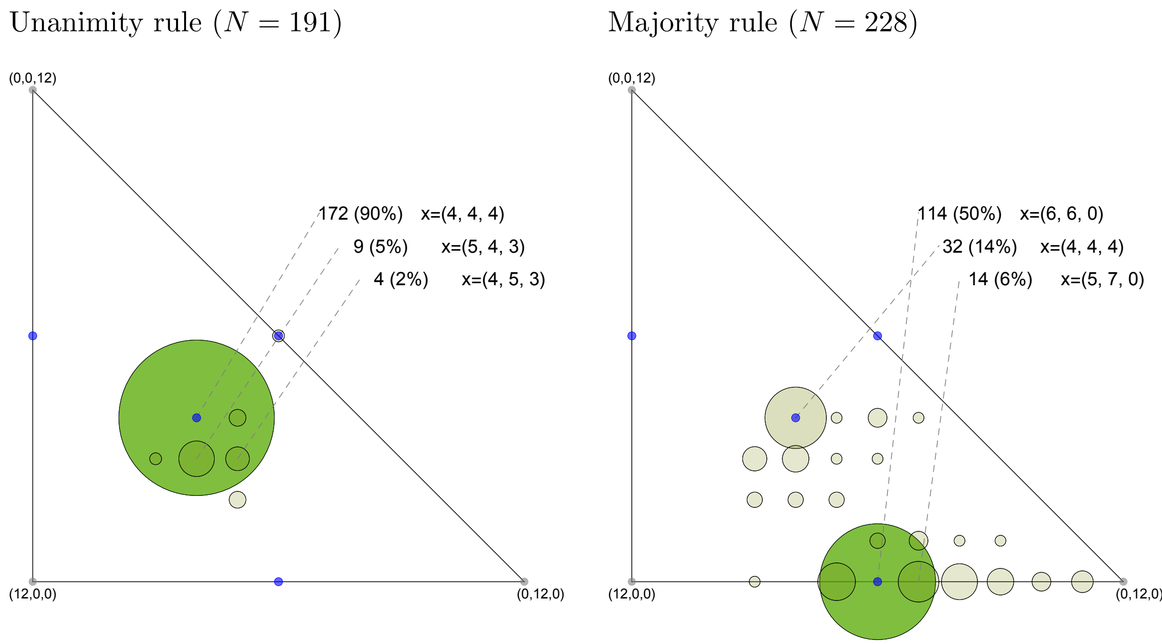


Figure 3: Distribution of final agreements (bubble plot). See the text for a description for how this figure is constructed.

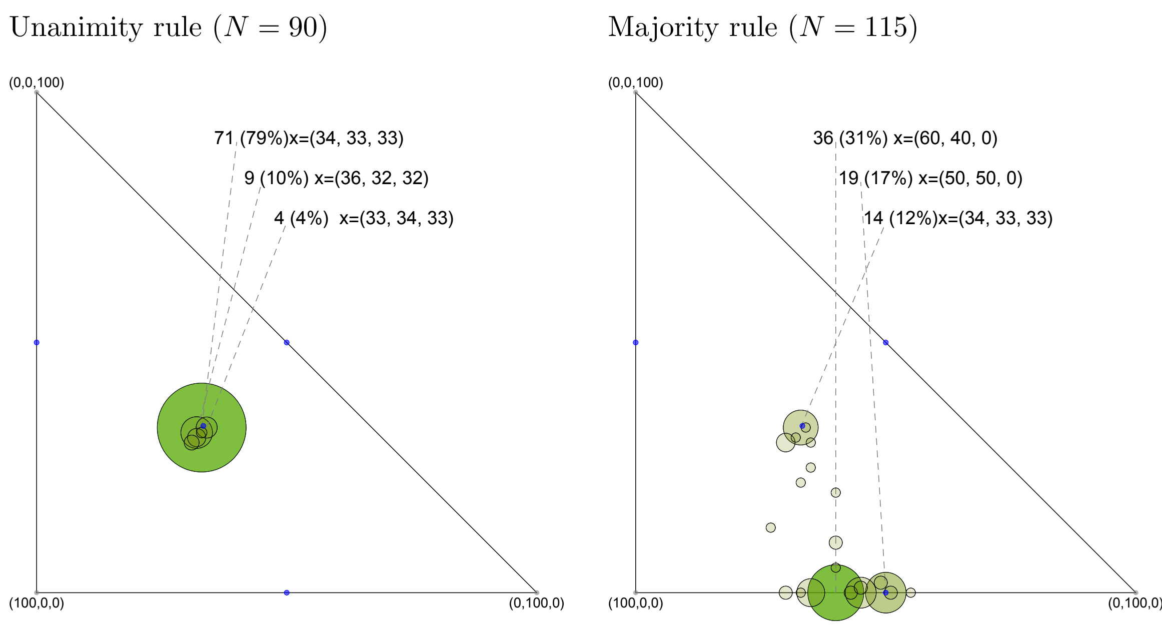


Figure 4: Distribution of final agreements in Miller and Vanberg 2013 (bubble plot). The figure is constructed the same way as Figure 3. These data are from a standard BF game with discount factor $\delta = .9$.

Table 3: Frequency of Minimum Winning Coalitions (final agreements)

	All periods	Periods 7-12
Majority rule	72%	83%
	(165/228)	(95/114)
Unanimity rule	> 99%	100%
	(190/191)	(96/96)

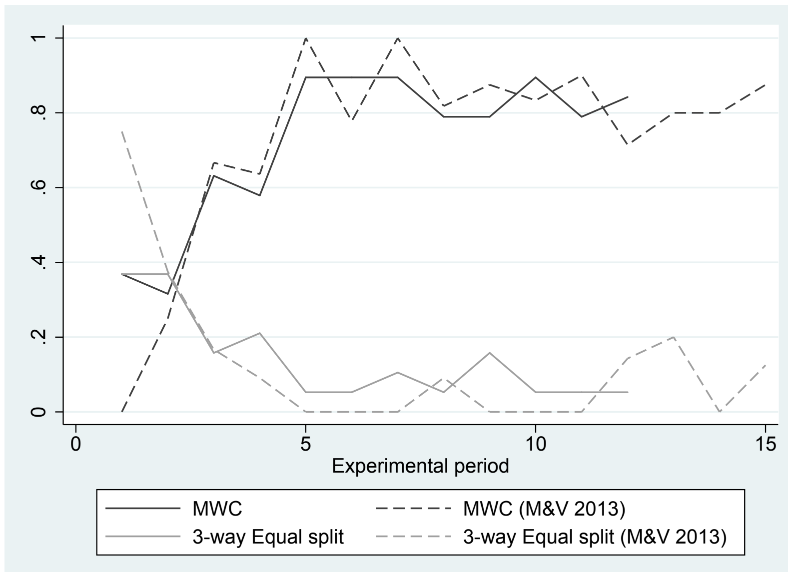


Figure 5: The fraction of final agreements under majority rule that constitute minimum winning coalitions (MWC) and equal (three-way) splits, by experimental period. The dashed lines represent data from a prior experiment using the Baron-Ferejohn protocol and a discount factor of $\delta = .9$ (Miller and Vanberg 2013).

rule constitute MWCs, i.e. give positive shares to all participants.[9] More interestingly, 73% of agreements under majority rule assign one player a payoff of zero. As can be seen in Figure 5, this percentage increases from 37% in the first period to 84% in the final period of the experiment. At the same time, the percentage of three-way equal splits declines from initially 37% to 5%. Again, this pattern closely mirrors the one observed in the structured experiments conducted by Miller and Vanberg (2013), also visible in Figure 5.

[9]The one exception was a game that went on for nearly two minutes, at which point one player, perhaps losing patience, suggested a fifty-fifty split between the others, to which all agreed.

Result 2 *The preponderance of final agreements constitute minimum winning coalitions. Under majority rule, the frequency of such coalitions increases over the course of the experiment. (Consistent with Hypothesis 2.)*

5.3 Proposer (dis)advantage

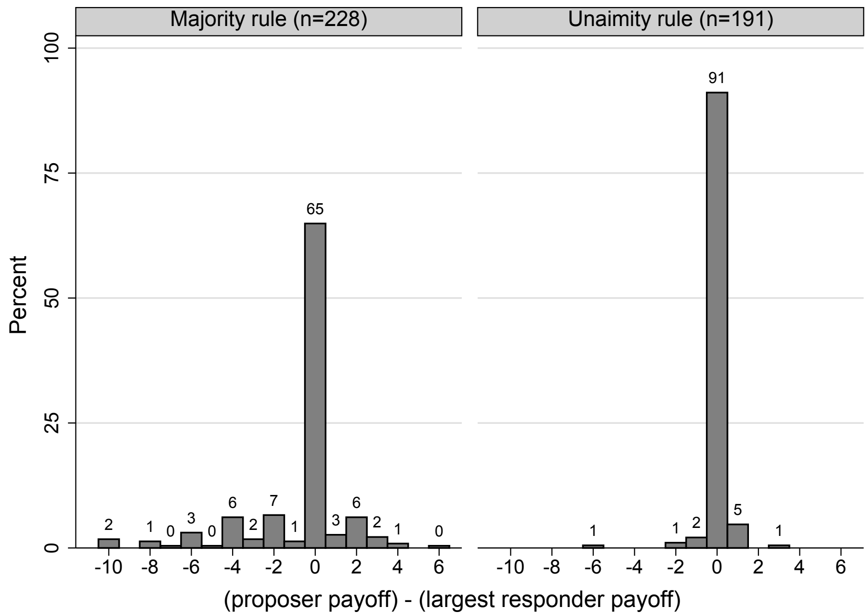
As noted above, an important difference between our unstructured environment and the classic BF game is that no subject is in a privileged procedural position. That is, no subject is exogenously given the role of 'proposer'. Instead, all subjects can act as 'proposers' by clicking on an unoccupied point within the simplex. Our conjecture (see Section 4) was that this will lead to more *equal* splits being proposed and agreed upon, as compared to experiments based on the BF game. This conjecture is confirmed by the data, although with an unexpected twist.

As we already saw in Figure 3, the vast majority of unanimity rule games end with agreement on the three-way equal split. Under majority rule, in turn, most MWC agreements constitute 50-50 splits (69% overall, 73% when focusing on the final 6 periods). Thus our conjecture is partially confirmed. More surprisingly, most of the remaining MWC agreements allocate *less* than 50% to the proposer, defined as the subject who first clicked on the agreed-upon point.

Another way to present this phenomenon is displayed in Figure 6, which presents a histogram of the difference between the share allocated to the proposer and the *largest* of the responder shares. Under unanimity rule, that difference is zero in 91% of all cases, and close to zero otherwise. Under majority rule, the pattern is more complex. In approximately 35% of all cases, the difference is non-zero, and in approximately 2/3 of those cases (23% overall), it is *negative.* Thus, the subject who first 'proposes' the agreed-upon point often receives strictly less than (at least) one of the other two players.

Result 3 *The subject making the implemented proposal does not receive more than an equal share of the surplus. Under majority rule, most unequal splits are to the disadvantage*

Figure 6: Difference between the proposer's share and the largest responder share



of the proposer. (Inconsistent with Hypothesis 3.)

5.4 Individual Strategies

In this section we provide some exploratory analysis which examines in more detail the types of strategies that are associated with securing a greater payoff. We focus on the final payoffs of subjects rather than the share of the final surplus to take into account the negative effect of delay that may be induced by particular strategies. Our analysis is at the subject level and relates average payoffs to behaviour over the 12 games in which they participated.

The rich variety of behaviour and possible contingent strategies means that entering into too much detail rapidly reduces the number of observations per strategy and precludes statistical analysis. Therefore we utilize a simple categorization: *aggressive/acquiescent* clicks are clicks where the subject would receive a greater/less than equal share of the surplus available to a MWC (one third in unanimity rules, one half in majority rules).[10] We use as explanatory variables the proportion of clicks over the 12 games that fall into these categories. Separate variables are calculated using all clicks, only those where the subject is clicking on a previously empty circle (proposals), and those where subjects are agreeing to an existing proposal (acceptances). We also consider the number of times a subject was the initial proposer to see if early offers are more important in influencing outcomes and, in majority rules, the proportion of clicks that are consistent with seeking a MWC (i.e. proposals on the edge of the simplex).

Unanimity Rule

Table 4 reports regressions of average payoffs on the variables described in the previous section. A higher proportion of *both* aggressive and acquiescent clicks (whether based on all clicks, or limited to proposals) is associated with significantly lower average payoffs (as compared to clicking only on the three-way equal split). We investigate the impact of making the first proposal, as reflected by the coefficient on the 'firstclicks' variable, which measures the number of games (out of 12) in which a subject was the first to click on the simplex. There is no evidence that clicking first under unanimity rules is either advantageous or disadvantageous.[11]

Majority Rule

As can be seen in Table 5, both aggressive and acquiescent strategies are again ineffective, associated with significantly lower payoffs (as compared to clicking on a two-way equal split). Aggressive proposals reduce average payoffs by nearly twice as much as acquiescent proposals. Seeking a MWC, however, appears to be an effective strategy, as a higher

[10] Clicks on an equal share provide the baseline in our regression analysis.

[11] Interestingly, detailed inspection of individual majority rules games finds some evidence in line with the insights of the bilateral bargaining model of Abreu and Gul (2000) which involves "behavioural types" who demand a greater share of the surplus and never give in, leading to delay as players use costly delay to imitate these types: in 18 of the 19 games where a subject received more than one third of the available surplus, agreement occurred in the second round or later, and in a large majority of cases subjects who obtain the lion's share in a game never click on a point where they would receive a third or less. See Embrey et al. (2014) for a laboratory implementation of this model.

Table 4: Relationship between clicking behavior and final payoffs (unanimity rule)

	(1)	(2)	(3)	(4)
clicks > 4	-8.16***			
	(1.88)			
clicks < 4	-26.10***			
	(5.31)			
props > 4		-3.50**		
		(1.09)		
props < 4		-25.01***		
		(6.07)		
accpts > 4			-17.77**	
			(5.00)	
accpts < 4			-6.94	
			(5.99)	
firstclicks				-0.07
				(0.08)
constant	32.27***	30.67***	30.99***	28.69***
	(0.80)	(0.85)	(0.92)	(1.17)
R-sqr	0.446	0.279	0.425	0.002

Standard errors clustered by matching group in parentheses. The dependent variable is the average payoff, as a *percentage* of the initial pie. The first 6 independent variables are defined as the *fraction* of all clicks (resp. all proposals, all acceptances) that fall into the respective intervals. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5: Relationship between clicking behavior and final payoffs (majority rule)

	(1)	(2)	(3)	(4)	(5)	(6)
clicks > 6	-30.24***					
	(7.53)					
clicks < 6	-27.87***					
	(3.76)					
props > 6		-28.16***				-20.58**
		(6.83)				(6.16)
props < 6		-18.49***				-10.64*
		(4.00)				(4.81)
accpts > 6			-5.11			
			(5.89)			
accpts < 6			-16.69**			
			(5.66)			
firstclicks				1.42***		
				(0.27)		
props on edge					17.93***	12.22***
					(3.74)	(3.21)
constant	50.27***	45.76***	40.14***	26.32***	21.79***	33.77***
	(2.42)	(2.27)	(3.22)	(1.01)	(2.23)	(3.52)
R-sqr	0.416	0.376	0.174	0.180	0.362	0.500
dfres	6	6	6	6	6	6

Standard errors clustered by matching group in parentheses. The dependent variable is the average payoff, as a *percentage* of the initial pie. The first 6 independent variables are defined as the *fraction* of all clicks (resp. all proposals, all acceptances) that fall into the respective intervals. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

proportion of clicks on the edge of the simplex is associated with higher average payoffs. This holds true when controlling for aggressive or acquiescent tendencies.

In contrast to unanimity rule, here it pays off to be the first proposer: the estimate implies that a subject who clicked first in each of the 12 games would earn 17p.p. more of the initial surplus on average, compared to a subject who never clicked first. An alternative approach to addressing this question is to consider individual games rather than aggregating payoffs by subject: the first subject to click earns 36% of the surplus on average, compared to 30% for those who click later (Wilcoxon signed-rank test $p = .02$).

6 Discussion and Conclusion

We ran an experiment which implements the substantive, but not technical, assumptions of the Baron-Ferejohn model and tested predictions about the outcomes under majority and unanimity rule generated both by the predictions of the original non-cooperative model (BF) and the results of an earlier structured experiment (MV). Predictions regarding the formation of minimum winning coalitions (from BF and MV) and greater delay under unanimity rule (from MV) are supported. This is good news for the BF model and experiments based on it, as it shows that the main substantive results (theoretical and experimental) are not driven by the imposition of technical procedural rules, but reflect robust patterns when groups make decisions using majority or unanimity rule. This is particularly interesting with the regard to delay under unanimity rule, where a possible reason for the delay observed in MV was exactly a clash between the exogenously imposed proposer power and fairness norms: we show that excessive delay occurs even in a perfectly symmetric environment.

Contrary to the theoretical predictions of BF and the experimental results of MV, in majority rule we find that the player who proposed the final division does not on average receive the lion's share. A possible explanation for this "proposer *dis*-advantage" is that the unstructured environment induces strong competition for inclusion in a winning coalition. This may force subjects to propose points that are attractive to potential coalition partners. The pressure to do so may be especially pronounced when a coalition between the other two subjects is already 'pending' (recall that agreements are finalized after a 5-second ratification interval). If two subjects have temporarily agreed to a 50-50 split (the most common agreement), the excluded player can only break this agreement by offering one player more than half, resulting in a disadvantageous proposal.

More exploratory analysis of bargaining strategies show that proposing and agreeing to equal splits among a minimum winning coalition are more profitable than seeking more, or agreeing to less, than one's "fair share". Furthermore, aiming for a minimum winning coalition and making the first proposal are advantageous strategies under majority rule.

In summary, we have shown that the experimental implementation a model without the technical assumptions can be useful for both demonstrating which theoretical predictions are robust to relaxing those assumptions (and thus more likely to be of relevance in real world environments), and generating novel hypotheses which can inform empirical work.

The assumptions of applied theory papers are seldom met in the real world, but all are motivated by the claim that the equilibrium analysis of a simplified model has something to say about a much more complicated reality. Yet in experimental economics a premium is placed on faithful implementation of the model. It is a great strength of experiments that they can relax some of the technical assumptions imposed by necessity in theoretical analysis, and this is a strength we feel should be more often exploited. We have illustrated this with a study of multilateral bargaining, an area where our point is of particular relevance. However, there are many more fields where such an approach would be fruitful, such as network formation (Teteryatnikova and Tremewan, 2015) and matching models where the somewhat unrealistic assumption of simultaneity of moves is often imposed. We would like to see more work following this approach, perhaps as additional treatments to more precise implementations of theoretical models.

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A Instructions (for unanimity treatment)

Subjects received both printed and onscreen instructions.

Onscreen Instructions (1)

The first screen contained the following text:

In this experiment, participants will interact in groups of three. The interaction will be repeated a number of times. In what follows, we will call each repetition of the interaction a "round".

During each round, the three members of a group will have the opportunity to distribute up to 1000 points amongst themselves.

The points you receive will determine how much money you earn at the end of the experiment (exactly how will be explained later, but the more points you receive, the more money you can expect to earn).

In addition to the money you earn during the interactions, you will also receive a payment for filling in a questionnaire.

In order to help you understand exactly how the interactions work, we will now demonstrate the functioning of the program on your screen.

There will be a short tutorial.

In the tutorial you will be shown the screen that will be used during the real rounds. How to understand this screen and use it to interact with the other participants in your group is explained to you in the printed instructions you have been given.

During this tutorial no money will be awarded0. The purpose of this tutorial is only to help you understand how the program works. You will be informed before the real interactions begin.

Please follow the printed instructions carefully. It is important to understand how the program works!

PLEASE CLICK "Begin Tutorial" IF YOU ARE READY TO BEGIN THE TUTORIAL

Printed Instructions

The following instructions were provided in hardcopy. The tutorial exercises were conducted onscreen while reading the instructions.

Tutorial Stage 1: DO NOT CLICK "Move to stage 2" UNTIL YOU ARE SPECIFICALLY ASKED TO IF YOU HAVE ANY QUESTIONS, RAISE YOUR HAND AND SOMEONE WILL COME TO ASSIST YOU.

Basics

- During this experiment, you will be interacting with other participants in groups of three.
- The participants in your group will decide how to divide a certain number of points amongst yourselves, which will later be converted into monetary payments.

- On your screen, you will see small circles arranged in the form of a large triangle. Each circle represents a different way of allocating the points amongst you and the other two participants you are interacting with in a given round.
- The corners of the triangle are labeled “You”, “Participant A”, and “Participant B”. The closer a point is to a given corner, the more the corresponding allocation assigns to that participant. The points in the corners correspond to allocations in which the indicated participant receives all available points, while the others receive no points.
- If you move your mouse over a circle, the corresponding points to be allocated to each participant are displayed in the appropriate corners of the triangle.
- Exercises:
    1. Move your mouse around the triangle until you understand how the circles are arranged. (This example assumes that there are 1000 points available)
    2. Click on a point to select it (for now, do not click on the circles that are already marked). Notice that the selected point is circled in green.
    3. Click on a point outside the triangle. The green ring should disappear.
        - During the real interactions, when you click on a circle this will be shown on the screens of the two other participants you are interacting with, and it will disappear from their screens if you click outside the triangle.
        - If all three participants select the same circle continuously for 5 seconds, the available points are allocated accordingly.

Making agreements

- During the real interactions, any of the three participants (including you) may click on any circle at any time.
- When you click on a circle, the other two participants in your group will see this circle marked on their screen. (On their screen you will be identified as “Participant A” or “Participant B”)
- When another participant in your group clicks on a circle on their screen, it will be marked on your screen in the color corresponding to that participant: orange for “Participant A”, blue for “Participant B”. You can see how this looks on your screen (note that the two coloured rings on your screen have been selected randomly by the computer).
- Clicking on an unmarked circle is like suggesting that division.
- Clicking on a circle marked by another participant is like provisionally accepting the division they have suggested. The offer will only be really accepted and determine the number of points earned in that round if all three participants click on the same circle, and no one clicks elsewhere in the following 5 seconds.
- Now you cannot form an agreement because the orange and blue rings are on different circles, and all three (including your green circle) must be on the same circle.
- When there is a provisional agreement in place, a red dot will appear in the corresponding circle, and the number of points that each participant would get if the provisional agreement is finalized

is shown in red in the appropriate corner of the triangle. In addition, a clock showing the time remaining until the agreement is finalized is displayed in red. (You can see a picture of the screen at the end of this document.)

Points available and the time limits

- The number of points that are available to be shared depends on how long it takes to reach an agreement.
- At the beginning of each round there will be 1000 points available in total.
- After every 10 seconds the number of points will be reduced by a factor of 9/10, i.e. if you make an agreement in the first 10 seconds there will be 1000 points available, if you make an agreement in the second 10 seconds there will be 900 points available, if you make an agreement in the third 10 seconds there will be 810 points available, and so on. (Points shown on the screen will be rounded to the nearest integer.)
- Note that the number of points received depends on when the agreement was first reached. For example, if the final agreement was first agreed upon when there were 900 points available you will be dividing the full 900 points even if the number of points is reduced to 810 in the following 5 seconds.
- The number of points available at a given point in time will be shown at the top left of the screen.
- To the right of this you will see a countdown to tell you when the points available will be reduced.
- If there is no agreement after 3 minutes, the round will end and all the participants in your group will earn zero points.

Tutorial Stage 2:

- When you click "Move to stage 2" two things will happen:
  - Instead of being on different circles, the blue and orange rings will appear on the same randomly chosen circle in the triangle.
  - The clock will start and the points available will start to decrease. Don't worry! The points received in this tutorial will not affect how much money you earn in this experiment. Also, you can repeat this part of the tutorial as many times as you like.
- There will be only two differences between Stage 2 of the tutorial and the real interactions:
  - In the tutorial rounds the points you will receive will not affect how much money you earn.
  - In the real interactions the blue and orange rings may move as the participants you are interacting with click on different circles on their triangles.
- CLICK ON "Move to stage 2" and complete the following exercises
- Exercises:
  - Watch the top line of the screen and see how the points available decrease when the "Points reduced in _ seconds" reaches zero.

- Click the blue and orange rings and see how the "Time until agreement" starts counting down until zero, when the round will "end" and the number of points you receive is determined. Then click "Play another tutorial round."
- Now try clicking on the blue and orange rings then clicking on an empty circle or outside the triangle before the 5 seconds are up. See how the "Time until agreement" starts counting down and then disappears when you click elsewhere.
- You can now experiment with the tutorial screen as much as you like. For example, try forming an agreement less than 5 seconds before the points available are reduced and check how many points you are allocated.

When you have understood how the interactions work, click on "Finish tutorial." When all participants have finished the tutorial, the real interactions will begin.

Onscreen Instructions (2)

The final screen of the tutorial contained the following text:

You have finished the tutorial.

You will now interact 12 times with **real participants**.

The participants with whom you will interact will change randomly at the beginning of each round.

The other participants in your group will always be referred to on your screen as "Participant A" and "Participant B", but **they will not be the same people in each round**.

At the end of the experiment, **one** of these rounds will be randomly selected and you will be paid according to the number of points you have earned in that round, and that round only.

Each point will be worth 3 cent, so the amount of money to be distributed in the selected round in each group is **30 Euros**.

You may now ask questions about the instructions on this page and way the program works, **however please do not ask questions about strategies and divisions you or the other players may have used, or may use in the future** . These types of questions will not be answered.

If you have a question, please raise your hand and ask it **quietly** when an experimenter comes.

If you have no questions, please click "Continue" and wait for the **real rounds** to begin.